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Complete Ensiled Rations for Lactating Dairy Cows: Corn Silage with Meal vs. Pelleted Concentrate and Alfalfa Silage with Meal Concentrate Added at Time of Ensiling

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Complete Ensiled Rations for Lactating Dairy Cows: Corn Silage with Meal vs. Pelleted Concentrate and Alfalfa Silage with Meal Concentrate Added at Time of Ensiling

J. W. HIBBS and H. R. CONRAD[1]

SUMMARY

An experiment was conducted to compare complete corn silage to which concentrate (59.7% of the dry matter) was added as meal at time of ensiling with complete corn silage to which a similar amount of concentrate in pelleted form was added prior to ensiling. No evidence of improved performance of lactating cows resulted when the concentrate was protected from the silage fermentation by pelleting. Digestion balance trials showed that nitrogen retention was lower when the concentrate was pelleted. The concentration of rumen volatile fatty acids was higher in the pelleted concentrate group, suggesting that rumen fermentation was more rapid.

Although crude protein was 15.1% in the complete silages, the addition of soybean meal after the end of the experimental period resulted in increased dry matter intake and milk yield.

In the second experiment, complete alfalfa silage to which the concentrate (33.0% of the dry matter) was added as meal at time of ensiling was compared with a standard control diet, 1 part alfalfa, 1 part corn silage, and 1 part concentrate by weight (as fed). The decline after the peak in milk production was the same in both groups, 0.110 kg/day, and was faster than that of cows fed the complete corn silage, average 0.075 kg/d, in experiment 1.

Feed efficiency for milk production was lower in the cows fed the complete alfalfa silage compared to those fed the 1-1-1 standard diet. The lower milk production in the cows fed complete alfalfa silage occurred despite their higher dry matter intake and reflected the low dry matter and nitrogen digestibility compared to either the cows fed the 1-1-1 ration or the corn silage groups in experiment 1. This may have been the result of excessive heating in the silo and was likely associated with the high dry matter content (53.3%) of the complete silage.

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INTRODUCTION

The primary purpose of the research reported here was to determine if it would be advantageous to pellet the concentrate prior to adding to chopped whole corn plant at time of ensiling to make a complete corn silage based diet. It was thought that perhaps pelleting the concentrate would protect some of the starch from the silage fermentation, leaving more readily available carbohydrate for the rumen fermentation, when subsequently fed to lactating cows. A second experiment was conducted to compare the performance of lactating cows fed a standard alfalfa hay, corn silage, concentrate diet with cows fed a complete alfalfa silage which included a meal concentrate added at time of ensiling.

In three previous experiments, Hibbs and Conrad (1) reported that cows fed complete corn silage diets, where the concentrate was added at time of ensiling, were on the average more efficient for milk production than when the same concentrate was added to corn silage at feeding time. They consumed an average of 0.7 kg less dry matter per day, produced 0.5 kg more 4% fat corrected milk (FCM) per day, and declined in milk yield 0.017 kg per day slower than the cows fed the same concentrate mixed with the corn silage at feeding time. In two of the three experiments (1), where extra soybean meal was not added at feeding time, dry matter intake was 1.7 kg/day higher when the concentrate was added at feeding time and thus not subjected to the fermentation in the silo. The increased dry matter intake did not result in higher yields of milk in these experiments.

Based on an earlier experiment, Pratt and Conrad (5) concluded that for highest dry matter intake and milk production, some unfermented grain or hay is needed to supplement high moisture grass-legume silage. This was further supported by Hibbs *et al.* (2), who showed higher dry matter intake and milk production when the concentrate was added to grass silages at feeding time than when the same concentrate was added at time of ensiling.

Using a complete feed corn silage, Pardue *et al.* at the University of Georgia, Athens, (4) found no differences in the performances of cows when a 20% protein concentrate was added at time of ensiling compared to the same concentrate added to corn silage at feeding time. The concentrate mixture provided 40% of the dry matter in these diets.

Hooven *et al.* at the USDA, Beltsville, (3) compared a complete corn silage based diet containing 40% concentrate (27.9% protein) on the dry matter basis with a control diet consisting of corn silage fed free choice plus alfalfa hay fed at 0.5% of body weight plus the same concentrate mixture fed at 1 kg for each 3 kg of milk produced. In early lactation the control cows ate more dry matter and produced more milk than the cows fed the complete silage diet. In late lactation, there were no differences between the two rations.

EXPERIMENTAL PROCEDURE

Experiment 1

Two 10 x 40-foot concrete stave silos were filled with chopped whole corn plant between Sept. 23 and 25, 1968. Alternate weighed loads from the same fields were blown into the two silos. For each 7 kg of wet chopped whole corn plant in each load, 1 kg of concentrate (D-186-68) was spread evenly over the top of the load prior to blowing into the silo to make a complete corn silage-concentrate diet. The concentrate mixture added to the southwest silo (control) was in the form of meal consisting of ground shell corn 57.3%, soybean meal 30.0% (50% crude protein), dehydrated alfalfa 5.0% (17% crude protein), urea 3.52%, bone meal 3.2%, and iodized salt 0.96%. The concentrate added to the northwest (experimental) silo was the same except that it was made into ⅝-inch pellets prior to ensiling.

Average dry matter of the fresh chopped whole corn plant sampled from each load was 25.7%. The dry matter of the added concentrate was 88.3%. Dry matter of the complete diet was 33.5% at time of ensiling. Thus, on the dry matter basis the complete corn silage-concentrate diets consisted of 67.2% chopped whole corn plant and 32.8% concentrate mixture.

Assuming that 50% of the chopped whole corn plant dry matter was ears and 20% of the ear was cob, the relative amounts of roughage and concentrate in the complete diets were estimated to be roughage 40.3% (stover and cob) and concentrate 59.7% (added concentrate plus the kernels on the ears) on the dry matter basis.

The complete diets, based on 16 samples taken weekly during the subsequent feeding experiment, averaged 38.0% dry matter and 15.1% crude protein. Digestible crude protein was estimated to be 10.5%, (percent total crude protein x 0.93) —3.5 (7).

On Oct. 28, 1968, after a 5-week fermentation, the silos were opened and a feeding trial was begun on Oct. 31, 1968, to measure possible differences in the silages. Two similar groups of seven cows, five Holsteins and two Jerseys in each group, were selected. The control group was fed the complete corn silage diet containing meal concentrate free choice during the entire 114-day feeding trial beginning on Oct. 31, 1968, and ending on Feb. 21, 1969. The experimental group was fed the complete corn silage concentrate diet containing the pelleted concentrate free choice during the same period.

At the beginning of the feeding trial the control cows weighed an average of 553 kg and the experimental cows weighed 572 kg. The control cows averaged 66 days of lactation and the experimental cows averaged 61 days of lactation at the beginning of the feeding experiment.

Criteria for measuring differences in the complete silages were 4% fat corrected milk, milk fat percent, body weight changes, dry matter, estimated net energy (lactation), crude protein intake, and productive efficiency for net energy. Digestibility of dry matter, protein, and stored nitrogen was based on 5-day digestion balance trials using three Jersey cows from each diet group. The following blood constituents were measured on three different dates during the feeding period and averaged: serum iodine, protein-bound iodine (PBI), cholesterol, and urea nitrogen. Acetic acid, propionic acid, butyric acid, isovaleric acid, valeric acid, caproic acid, and total volatile fatty acids content in the rumen juice were also measured on Dec. 31, 1968, 61 days after the feeding experiment began.

Experiment 2

During the summer of 1968, a 14 x 50-foot Harvestore silo was filled intermittently from June 9 until Sept. 7 with a mixture of two-thirds chopped alfalfa dry matter and one-third concentrate dry matter. The concentrate was mixed with the loads of chopped alfalfa as described in experiment 1. The concentrate (D-165-68) consisted of ground shelled corn 95.15%, di-ammonium phosphate (duofos) 3.65%, and iodized salt 0.12%. The dry matter content of the alfalfa at ensiling varied considerably during the season and averaged 48%. The concentrate averaged 90% dry matter. The average dry matter content of the silage in the entire silo was calculated to be 61.9%. The dry matter of the complete silage sampled as fed free choice to four Holstein cows during the subsequent 114-day feeding experiment (Dec. 1, 1968, to April 1, 1969) averaged 53.3%. The crude protein content averaged 16.6% and the digestible protein averaged 11.9%. Percent digestible protein = (percent crude protein x 0.93) —3.5 (7).

The following measurements were made during a 114-day feeding trial that extended from day 24 of lactation (four Holstein cows) to day 138 of lactation: milk production, fat production, body weight changes, dry matter intake, and crude protein intake. Digestibility of dry matter, protein, and stored nitrogen was determined as in experiment 1.

For comparison with the cows fed complete meal-concentrate alfalfa silage, the same measurements were obtained in a 114-day feeding trial from seven control Holstein cows, beginning at 24 days of lactation and extending 114 days to 138 days of lactation. The control cows were fed a standard (1-1-1) diet to appetite containing approximately 18% crude protein (DM basis) and consisting of 1 part alfalfa hay, 1 part corn silage, and 1 part concentrate on the as fed basis. The concentrate, D-113-66, consisted of burr milled corn 50%, crimped oats 20%, soybean meal 27.4%, bone meal 2%, and iodized salt 0.6%. Taking into consideration the corn kernels in the corn silage, the standard (1-1-1) diet contained approximately 49.3% concentrate and 50.7% roughage on the dry matter basis. No data on blood constituents or rumen fatty acids were obtained from the cows fed the 1-1-1 diet. Dry matter digestibility was determined on the seven cows fed the 1-1-1 diet using a chromic oxide method (8).

RESULTS AND DISCUSSION

Experiment 1

In Table 1, the complete corn silage containing meal-concentrate (control) is compared with the complete corn silage containing pelleted-concentrate (experimental) on the basis of milk production and milk fat, changes in body weight, dry matter and protein intake and digestibility, estimated net energy (lactation), and productive efficiency. None of the measurements shown in Table 1, experiment 1, differed statistically (analysis of variance).

Estimated net energy (lactation) of the complete corn silage diet was 1.65 mcal/kg. Net energy (lactation) productive efficiency (mcal in milk + BW gain ÷ mcal in feed) for the meal-concentrate diet was 61.4% and for the pelleted-concentrate diet 58.9%.

The relation of milk production to time (day of lactation) during the 114-day experiment is shown in Fig. 1. The rate of decline in milk production after the peak (Fig. 1) was similar in both groups, 0.070 kg/day for the meal-concentrate group and 0.081 kg/day for the pelleted-concentrate group during the 114-day experiment.

Table 2 shows the results of 5-day digestion balance trials using three Jersey cows from each diet group. The only significant differences observed were the lower percentage of feed nitrogen excreted in the urine (41.2% vs. 48.3%) and the higher percentage of feed nitrogen stored (13.0% vs. 5.9%) in the control (meal-concentrate) group compared to the experimental (pelleted-concentrate) group, respectively. These differences likely reflect the greater nitrogen efficiency caused by a lower rate of rumen fermentation in the cows fed the meal-concentrate silage as indicated by the lower rumen fatty acid concentration (Table 3).

Table 3 shows the average content of the individual rumen volatile fatty acids as well as the total rumen volatile fatty acids. All fatty acid values were significantly higher in the experimental (pelleted-concentrate) group. This suggests that pelleting the concentrate protected some of the concentrate from the silage fermentation, causing more readily available energy and increased fermentation in the rumen, than when the meal-concentrate silage was fed. Also shown in Table 3 are average values for serum cholesterol, serum total iodine, serum protein bound iodine (PBI), and serum urea nitrogen None of these average values was significantly different except serum urea nitrogen.

The higher serum urea nitrogen (SUN) (Table 3) in the control (meal-concentrate) group (17 6 mg/100 ml) compared to the experimental (pelleted-concentrate) group (15 8 mg/100 ml) cannot be readily accounted for in view of the lower percent urine nitrogen and the higher percent stored nitrogen observed in the digestion balance trial (Table 2) for the control (meal-concentrate) group The observed differences in serum urea nitrogen, urinary nitrogen, stored nitrogen, and rumen volatile fatty acids were not reflected in significant differences in performance of the cows in the two groups.

Figure 2 shows the (D-186-68) concentrate pellets, 3/8-inch diameter, before and after going through the silage fermentation, indicating a considerable degree of preservation in the silo.

It is concluded that pelleted-concentrate added to whole corn plant at time of ensiling to make a complete silage offers no significant advan-

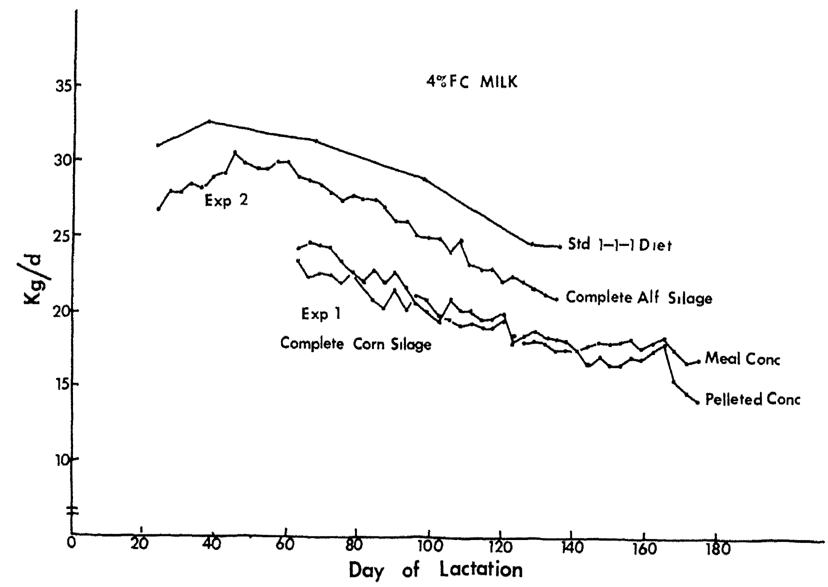

FIG. 1.—4% fat corrected milk, experiment 1 (complete meal-concentrate corn silage vs. complete pelleted-concentrate corn silage) and experiment 2 (standard 1-1-1 diet vs. complete meal-concentrate alfalfa silage). Time is shown as day of lactation.

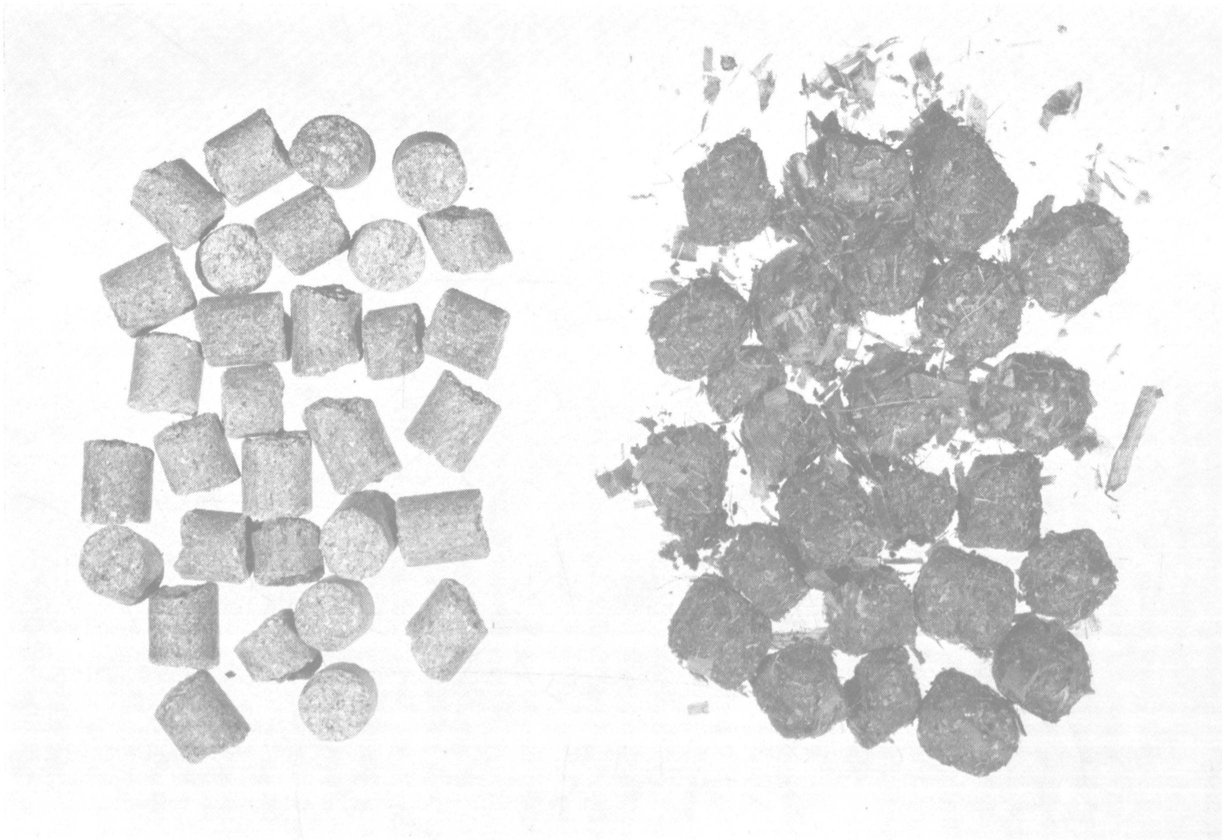

FIG. 2.—Pelleted diet, D-186-68, 3/8-inch pellets, before (left) and after (right) ensiling.

tage over the use of meal-concentrate as far as milk production is concerned. Indeed, pelleting the concentrate for this purpose can be expected to result in lowered nitrogen efficiency when the complete silage is fed, due to a more rapid rumen fermentation, with increased NH_3 loss through the rumen wall.

At the conclusion of this experiment, the cows were regrouped and continued on the complete silage they had been eating. One group was fed added soybean meal, 0.455 kg/d, and the other group was not fed added soybean meal. The Holstein group fed added soybean meal responded during the next 6 days with an increase in milk yield over the control group of 1.1 kg/day. Dry matter intake increased 0.56 kg/day during this period compared to the controls. Average production of these Holstein cows during the preceding 21 days had been 20 kg/day. During the next 9 days, 0.909 kg/day of soybean meal was added and milk yield increased another 0.35 kg/day while dry matter intake increased an additional 0.39 kg/day compared to the controls.

Since the crude protein in the complete silage was likely sufficient at 15.1% for this level of production, it is suggested that the added soybean meal may have provided the needed unfermented concentrate observed by Pratt and Conrad (5) to support maximum milk production when legume-grass silage was fed. Pratt and Conrad (6) also reported equal milk yields when legume-grass silage plus grain concentrate was compared with legume-grass silage plus ear corn silage plus soybean meal added at feeding time. The soybean meal was the only unfermented feed provided in the latter group.

The reason for the response to added soybean meal in the Holstein cows was not elucidated in this experiment. Perhaps it was the result of the provision of added rumen bypass protein or a combination of both bypass protein and the available energy provided by the soybean meal.

No response in milk yield was found in the Jersey cows receiving added soybean meal. The Jerseys were producing an average of approximately 10.4 kg of milk/day at the time soybean meal was added.

Experiment 2

Table 1 also shows the milk production, milk fat production, body weight changes and the dry matter, estimated net energy (lactation), crude protein intake and digestibility, and productive efficiency for net energy of four Holstein cows fed the complete meal-concentrate alfalfa silage (experimental). Values are also given for six Holstein cows fed the 1-1-1 standard diet that served as controls during the 114-day feeding experiment beginning at day 24 of lactation. The relation of milk production to time (day of lactation) during the feeding experiment is shown in Figure 1. The average peak milk production and body weight were both considerably higher in the control cows. However, the rate of decline after peak milk production was identical in each group, 0.11 kg/day. This rate of decline was considerably faster, 0.07 and 0.08 kg/day respectively, (Fig. 1) than in either the control or the experimental group in experiment 1 where complete corn silage was fed.

The lower feed efficiency for milk production of the complete alfalfa silage is the result of the lower milk yield and the extremely high intake of dry matter per unit of initial body weight compared to the cows fed the 1-1-1 diet. The fineness of chopping of the alfalfa combined with high rate of passage apparently permitted the excessively high dry matter intake, perhaps in an effort to meet the nitrogen needs for optimum milk yield in the face of the low nitrogen availability, only 60.5% digested. Estimated net energy (lactation) of the complete alfalfa silage diet was 1.58 mcal/kg and for the 1-1-1 diet was 1.59 mcal/kg. Net energy (lactation) productive efficiency (mcal in milk + BW gain ÷ mcal in feed) was 54.1% for the complete alfalfa silage compared to 72.9% for the 1-1-1 diet.

Although no evidence was found that in complete corn silage there was need for a source of unfermented feed (1), the data presented here support the evidence of Pratt and Conrad (5) and Hibbs *et al.* (2) that when complete alfalfa silage is fed, some added unfermented feed can be expected to enhance milk production, as it did in the 1-1-1 diet.

The lower milk production of the cows fed the complete alfalfa silage (Table 1) compared to the cows fed the 1-1-1 diet, despite their higher dry matter intake, was likely related to unavailability of the protein due to excessive heating in the silo, associated with the high dry matter (53.3%). This is further indicated by the low (60.5%) nitrogen digestion and zero nitrogen storage observed in the digestion trial (Table 2). Digestion data were not available for the cows fed the 1-1-1 diet, except dry matter digestibility which was determined by a chromic oxide method (8). The problem of excessive heating in the complete silage perhaps could have been avoided by less wilting of the forage before ensiling.

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TABLE 1.—Comparison of Milk and Milk Fat Production, Body Weight, and Dry Matter, Net Energy and Protein Eaten and Digested.

	Cows in Group	Concentrate in Total Dry Matter	Initial 4% F.C. Milk	Av. 4% F.C. Milk	4% F.C. Milk/ $BW^{0.75}$	Decline After Peak 4% F.C. Milk	Milk Fat	
		%	kg/d	kg/d	kg/d	kg/d	%	kg/d
			Experiment 1					
Complete Meal - Concentrate Corn Silage‡	7 (5H-2J)	59.7	24.2	20.0	0.175	0.074	3.9	0.78
Complete Pelleted - Concentrate Corn Silage‡	7 (5H-2J)	59.7	23.3	19.0	0.162	0.081	3.9	0.74
			Experiment 2					
Complete Meal - Concentrate Alfalfa Silage	4 (4H-0J)	33.0	26.7	26.4	0.214	0.110	3.2	0.85
Standard (1-1-1) Diet**	7 (7H-0J)	49.3	30.4	28.9	0.224	0.110	3.2	0.97

‡None of these average values are statistically different (analysis of variance).

**The standard (1-1-1) diet was approximately 1 part alfalfa hay — 1 part corn silage — 1 part concentrate (D-113-66) on the as fed basis.

TABLE 1 (Continued).—Comparison of Milk and Milk Fat Production, Body Weight, and Dry Matter, Net Energy, and Protein Eaten and Digested.

	Cows in Group	Initial Body Wt.	Final Body Wt.	Body Wt. Gain (114 d)	Dry Matter in Feed	Dry Matter Intake	Dry Matter Intake (Percent of Initial Body Wt.)	Dry Matter Digested	
	No	kg	kg	kg	%	kg/d	%	%*	kg/d*
				Experiment 1					
Complete Meal - Concentrate Corn Silage‡	7 (5H 2J)	553	606	53	38 0	17 0	3 07	73 4	12 5
Complete Pelleted - Concentrate Corn Silage‡	7 (5H 2J)	572	634	62	38 0	17 3	3 02	73 6	12 7
				Experiment 2					
Complete Meal - Concentrate Alfalfa Silage	4 (4H 0J)	614	661	47	53 3	25 3	4 01	67.7	17 7
Standard (1-1-1) Diet**	7 (7H 0J)	656	662	6	53 0	18 7	2 85	70.5	13 2

*Based on digestion balance trials using Jersey cows (see Table 2)
‡None of these average values are statistically different (analysis of variance).
**The standard (1-1 1) diet was approximately 1 part alfalfa hay — 1 part corn silage — 1 part concentrate (D 113 66) on the as fed basis.

TABLE 1 (Continued).—Comparison of Milk and Milk Fat Production, Body Weight, and Dry Matter, Net Energy, and Protein Eaten and Digested.

	Cows in Group	Crude Protein in Feed	Crude Protein Intake	Crude Protein Intake (Percent of Initial Body Wt.)	Crude Protein Digested		Est. Net Energy (Lactation)	Productive Efficiency
	No.	%	kg/d	%	%*	kg/d*	mcal/kg DM	%†
				Experiment 1				
Complete Meal - Concentrate Corn Silage‡	7 (5H-2J)	15.1	2.49	0.45	76.8	1.91	1.65	61.4
Complete Pelleted - Concentrate Corn Silage‡	7 (5H-2J)	15.1	2.59	0.45	75.5	1.96	1.65	58.9
				Experiment 2				
Complete Meal - Concentrate Alfalfa Silage	4 (4H-0J)	16.6	4.4	0.71	60.5	2.66	1.58	54.1
Standard (1-1-1) Diet**	7 (7H-0J)	18.3	3.4	0.51			1.59	72.9

*Based on digestion balance trials using Jersey cows (see Table 2).
†Estimated net energy (lactation) efficiency = mcal in milk + BW gain ÷ mcal in feed = productive efficiency of the diet.
‡None of these average values are statistically different (analysis of variance).
**The standard (1-1-1) diet was approximately 1 part alfalfa hay — 1 part corn silage — 1 part concentrate (D-113-66) on the as fed basis.

TABLE 2.—Results of 5-Day Digestion-Balance Trials.

	Dry Matter Eaten	Dry Matter Digested		Nitrogen Eaten	Nitrogen Digested	
	kg/d	%	kg/d	kg/d	%	kg/d
				Experiment 1*		
Complete Meal - Concentrate Corn Silage						
J1789	11.7	72.5	8.5	0.29	75.2	0.22
J1606	11.7	74.7	8.7	0.30	79.3	0.24
J1766	14.0	72.7	10.2	0.35	76.0	0.27
Av. (3)	12.5	73.4	9.1	0.31	76.8	0.26
Complete Pelleted - Concentrate Corn Silage						
J1806	15.3	71.8	11.0	0.40	73.1	0.29
J1850	10.7	75.7	8.1	0.28	77.4	0.22
J1693	18.4	73.3	13.5	0.48	75.9	0.36
Av. (3)	14.8	73.6	10.9	0.39	75.5	0.29
				Experiment 2*		
Complete Meal - Concentrate Alfalfa Silage						
J1687	18.1	69.6	12.6	0.42	63.0	0.27
J1859	12.2	65.9	8.0	0.28	57.9	0.16
Av. (2)	15.2	67.7	10.3	0.35	60.5	0.22
Standard (1-1-1) Diet**						
Av. (7)	—	70.5††	—	—	—	—

*The three Jersey cows used in the digestion trial were fed complete silages for 9 weeks prior to the 5-day digestion trial.

**The standard (1-1-1) diet was approximately 1 part alfalfa hay – 1 part corn silage – 1 part concentrate (D-113-66) on the as fed basis.

††Dry matter digestion determined by a chromic oxide method (8).

TABLE 2 (Continued).—Results of 5-Day Digestion-Balance Trials.

	Feed Nitrogen Stored		Feed Nitrogen in Urine	Feed Nitrogen in Milk	Feed Nitrogen in Feces
	kg/d†	%‡	%‡	%	%
			Experiment 1		
Complete Meal - Concentrate Corn Silage					
J1789	0.17	9.3	42.2	23.8	24.8
J1606	0.31	16.5	40.9	21.8	20.8
J1766	0.29	13.2	40.6	22.2	24.1
Av. (3)	0.26a	13.0a	41.2a	22.6	23.2
Complete Pelleted - Concentrate Corn Silage					
J1806	0.15	5.9	45.0	22.1	26.9
J1850	0.09	5.2	51.4	20.9	22.7
J1693	0.20	6.6	48.5	21.0	24.1
Av. (3)	0.15b	5.9b	48.3b	21.3	24.6
			Experiment 2		
Complete Meal - Concentrate Alfalfa Silage					
J1687	0.03	5.8	33.7	23.4	37.0
J1859	—0.03	—10.4	43.0	25.2	42.1
Av. (2)	0.00	— 2.3	38.4	24.3	39.6
Standard (1-1-1) Diet**					
Av. (7)	—	—	—	—	—

*The three Jersey cows used in the digestion trial were fed complete silages for 9 weeks prior to the 5-day digestion trial.

†Nitrogen stored is the amount consumed minus the amount collected in the feces, urine, and milk.

‡Average values followed by different letters were significantly different ($P < .05$) (analysis of variance).

**The standard (1-1-1) diet was approximately 1 part alfalfa hay – 1 part corn silage – 1 part concentrate (D-113-66) on the as fed basis.

TABLE 3.—Comparison of Rumen Volatile Fatty Acids and Serum Cholesterol, Iodine, Protein Bound Iodine (PBI) and Urea Nitrogen.

Experimental Group	Cows in Expt.	Acetic Acid	Propionic Acid	Butyric Acid	Iso-valeric Acid	Valeric Acid	Caproic Acid	Total Volatile Fatty Acids
	No.	μmoles/ml	μmoles/ml	μmoles/ml	μmoles/ml	μmoles/ml	μmoles/ml	μmoles/ml
				Experiment 1				
Complete Meal - Concentrate Corn Silage	7	51.5	18.4	10.7	3.5	2.4	1.2	87.5
Complete Pelleted - Concentrate Corn Silage	7	61.6*	23.4*	11.5*	4.2*	3.4*	1.7*	105.7*
				Experiment 2				
Complete Meal - Concentrate Alfalfa Silage	4	61.5	18.7	9.7	2.5	2.3	0.7	95.2
Standard (1-1-1) Diet‡	7	—	—	—	—	—	—	—

Experimental Group	Cows in Expt.	Serum Cholesterol	Serum Total Iodine	Serum PBI	Serum Urea Nitrogen
	No.	mg/100 ml[2]	mg/100 ml[2]	mg/100 ml[2]	mg/100 ml[2]
		Experiment 1			
Complete Meal - Concentrate Corn Silage	7	145	5.8	5.0	17.6†
Complete Pelleted - Concentrate Corn Silage	7	145	6.0	4.9	15.8
		Experiment 2			
Complete Meal - Concentrate Alfalfa Silage	4	157	4.8	3.4	14.7
Standard (1-1-1) Diet‡	7	—	—	—	—

*Averages were significantly higher than in the meal concentrate group. Rumen samples taken 12-31-68.

†Average of three blood samples taken during the feeding period (12-9-68 — 1-3-69 — 3-3-69). Serum urea nitrogen significantly higher ($P < .05$) in meal concentrate group.

‡The standard (1-1-1) diet was 1 part alfalfa hay — 1 part corn silage — 1 part concentrate (D-113-66) on the as fed basis.

BETTER LIVING IS THE PRODUCT

of research at the Ohio Agricultural Research and Development Center. All Ohioans benefit from this product.

Ohio's farm families benefit from the results of agricultural research translated into increased earnings and improved living conditions. So do the families of the thousands of workers employed in the firms making up the state's agribusiness complex.

But the greatest benefits of agricultural research flow to the millions of Ohio consumers. They enjoy the end products of agricultural science—the world's most wholesome and nutritious food, attractive lawns, beautiful ornamental plants, and hundreds of consumer products containing ingredients originating on the farm, in the greenhouse and nursery, or in the forest.

The Ohio Agricultural Experiment Station, as the Center was called for 83 years, was established at The Ohio State University, Columbus, in 1882. Ten years later, the Station was moved to its present location in Wayne County. In 1965, the Ohio General Assembly passed legislation changing the name to Ohio Agricultural Research and Development Center—a name which more accurately reflects the nature and scope of the Center's research program today.

Research at OARDC deals with the improvement of all agricultural production and marketing practices. It is concerned with the development of an agricultural product from germination of a seed or development of an embryo through to the consumer's dinner table. It is directed at improved human nutrition, family and child development, home management, and all other aspects of family life. It is geared to enhancing and preserving the quality of our environment.

Individuals and groups are welcome to visit the OARDC, to enjoy the attractive buildings, grounds, and arboretum, and to observe first hand research aimed at the goal of Better Living for All Ohioans!

The State Is the Campus for Agricultural Research and Development

Ohio's major soil types and climatic conditions are represented at the Research Center's 12 locations.

Research is conducted by 15 departments on nearly 7,000 acres at Center headquarters in Wooster, eight branches, Pomerene Forest Laboratory, North Appalachian Experimental Watershed, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 1953 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Jackson Branch, Jackson, Jackson County: 502 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Appalachian Experimental Watershed, Coshocton, Coshocton County: 1047 acres (Cooperative with the Science and Education Administration/Agricultural Research, U. S. Dept. of Agriculture)

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest Laboratory, Coshocton County: 227 acres

Southern Branch, Ripley, Brown County: 275 acres

Vegetable Crops Branch, Fremont, Sandusky County: 105 acres

Western Branch, South Charleston, Clark County: 428 acres